

UNITED STATES PATENT APPLICATION

OF

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FOR

THERMAL IMAGE IDENTIFICATION SYSTEM

## **BACKGROUND OF THE INVENTION**

### **Field of the Invention**

[001] The present invention relates to a thermal marker and, more particularly, to a thermal image identification system utilizing infrared energy.

### **Description of the Related Art**

[002] Thermal markers used for identification purposes are known in the art. Such markers have been used for various military and law enforcement applications. Conventional markers utilize a pouch containing chemicals that undergo an exothermic reaction on exposure to air to generate heat, and therefore infrared energy, for a period of time. The markers can be seen with special optical equipment, even under low visibility conditions.

[003] There are a number of shortcomings associated with conventional thermal markers. First, they have a limited operational life. Because the heat is generated by a chemical reaction, the marker is no longer usable once the chemicals have been depleted. At the end of its operational life, the conventional thermal marker is discarded.

[004] Further, use of conventional markers requires active participation by the wearer. A user must open a sealed pouch to expose the marker to air and initiate the heat-generating chemical reaction. For military and law enforcement personnel, this active initiation process may interfere with other activities necessary for self-preservation. Also, under extreme conditions, omission of this task could have catastrophic results.

[005] Further, coordinated thermal signaling among a discrete group of individuals is difficult at best. Because remote activation is not feasible, the markers must be continuously activated, leading to excessive visibility to potential enemies and premature depletion of chemical fuel.

### **SUMMARY OF THE INVENTION**

[006] To overcome the drawbacks of the prior art and in accordance with the purpose of the invention, as embodied and broadly described herein, one aspect of the invention provides a thermal image identification system, including an infrared emitting element having a laminate, and a power source electrically communicable with the infrared emitting element. The laminate includes an infrared emitting layer having a first side and a second side, a cover layer associated with the first side, and a backing layer associated with the second side.

[007] In another aspect, the invention provides an infrared emitting layer including a support having a first surface and a second surface, a first plurality of conductive elements disposed on the first surface, and a first layer of electrically conductive heating material disposed on the first plurality of conductive elements.

[008] In another aspect, the invention provides an infrared emitting layer further including a second plurality of conductive elements disposed on the second surface, and a second layer of electrically conductive heating material disposed on the second plurality of conductive elements.

[009] In a further aspect, the invention provides an infrared emitting layer including a support having a first surface and a second surface, and at least one resistive element disposed on the first surface.

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[010] According to a still further aspect, the invention provides a first heat insulating layer between the infrared emitting layer and the cover layer, a second heat insulating layer between the infrared emitting layer and the backing layer, and an infrared reflective layer between the second heat insulating layer and the backing layer.

[011] In yet another aspect, the invention provides a plurality of infrared elements arranged contiguously for coordinated operation. According to this aspect of the invention, the infrared emitting elements may be arranged in a one-dimensional or a two-dimensional array.

[012] In a further aspect, the invention provides a controller electrically communicating with the power source and with the plurality of infrared emitting elements. According to another aspect, the controller regulates at least one of an operating mode of the infrared elements, an illumination intensity of the infrared emitting elements, a temperature of the infrared emitting elements, and a voltage of the power source.

[013] In a still further aspect, the invention provides a method of marking a target, the method including providing a thermal image identification system, including an infrared emitting element comprising a laminate, securing the infrared emitting element to a target, and activating the infrared emitting element to generate infrared radiation. The laminate includes an infrared emitting layer having a first side and a second side, a cover layer associated with the first side, a backing layer associated with the second side, and a power source electrically communicable with the infrared emitting element.

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[014] Additional advantages of the invention will be set forth in part in the description that follows, and in part will be obvious from the description, or may be learned by practice of the invention. The objects and advantages of the invention will be realized and attained by the elements and combinations particularly pointed out in the appended claims.

[015] It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory only and are not restrictive of the invention, as claimed.

### **BRIEF DESCRIPTION OF THE DRAWINGS**

[016] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate several embodiments of the invention and together with the description, serve to explain the principles of the invention. In the drawings,

[017] Figure 1 is a schematic of an embodiment of the thermal image identification system of the present invention.

[018] Figure 2 is a schematic of an embodiment of the laminate of the infrared emitting element of the present invention.

[019] Figures 3a-3d are schematics of a thermal image identification system utilizing the infrared emitting element of Figure 2.

[020] Figure 4 is a schematic of another embodiment of the laminate of the infrared emitting element of the present invention.

[021] Figure 5 is a schematic of another embodiment of the laminate of the infrared emitting element of the present invention.

[022] Figure 6 is a schematic of a thermal image identification system utilizing the infrared emitting element of Figure 5.

[023] Figure 7 is a schematic of an embodiment of the thermal image identification system of the present invention.

[024] Figure 8 is a perspective view of an application of the thermal image identification system of the present invention.

[025] Figures 9a and 9b are schematics of other applications of the thermal image identification system of the present invention.

### **DETAILED DESCRIPTION OF THE INVENTION**

[026] Reference will now be made in detail to the present embodiments of the invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numbers will be used throughout the drawings to refer to the same or like parts.

[027] The thermal image identification system of the present invention provides a thermal marker that generates a unique infrared signature allowing identification and classification by a remote observer using an infrared imaging device. Applications include markers for personnel and equipment, and ground based markers.

[028] An embodiment of the thermal image identification system 10 will be described with reference to Figure 1. As shown, the system includes an infrared emitting element 12 that may be connected to a power source 18 with cables 14, 16. The power source 18 may comprise one or more batteries. For larger applications, an electric generator may be used.

[029] In this embodiment, the cables 14, 16 are provided with electrical connectors 20, 22, which allow a user to separate the infrared emitting element 12 from the power source 18. This arrangement allows the user to quickly replace the power source 18 when necessary, while continuing to use the same infrared emitting element 12. To ensure reliable operation in adverse environments, the system may utilize rugged, quick-disconnect type electrical connectors.

[030] The infrared emitting element 12 comprises a laminate, shown in Figure 2, having an infrared emitting layer 24 with a first side 26 and a second side 28. There is a cover layer 30 associated with the first side 26 and a backing layer 32 associated with the second side 28.

[031] The cover layer 30 comprises an infrared transparent material, such as polyethylene, and may be secured to the first side 26 of the infrared emitting layer 24 with non-conductive adhesive. This arrangement provides protection to the laminate, while allowing the emission of the infrared radiation generated by the infrared emitting layer 24.

[032] The backing layer 32 comprises at least one of a chemical fastener, a magnetic fastener, and a mechanical fastener, and may be secured to the second side 28 of the infrared emitting layer 24 with non-conductive adhesive. Fasteners such as hook and loop fasteners, adhesives, and magnets have been used. Other fasteners may also be used.

[033] The material of the backing layer 32 may be as flexible or as stiff as desired, depending on the end use of the thermal image identification system 10. The appropriate fastener and backing layer material may be chosen for a particular

mounting application. Examples of mounting applications include the clothing and helmets of personnel, harnesses for canine applications, and surfaces of equipment and other support structures.

[034] An embodiment of the laminate of the infrared emitting element 12 is shown in Figure 2. In this embodiment, the infrared emitting layer 24 comprises a support 34 having a first surface 36 and a second surface 38. A first plurality of conductive elements 40 is disposed on the first surface 36, and a first layer of electrically conductive heating material 42 is disposed on the first plurality of conductive elements 40.

[035] The conductive elements 40 may comprise copper electrodes, although other materials may also be used. In one embodiment, the conductive elements 40 and the support 34 are formed from a flexible printed circuit board. In a further embodiment, the support 34 comprises an insulating material. KAPTON has been used for this purpose, but other materials may be used.

[036] In one embodiment, the electrically conductive heating material 42 comprises a plastic film, such as conductive thin film, an example of which is described in U.S. Patent No. 4,422,646, incorporated herein by reference for a description of conductive thin films. Other materials may also be used. The first layer of electrically conductive heating material 42 may be secured to the first plurality of conductive elements 40 with conductive adhesive. A conductive adhesive such as IS8001-27 Conductive Double-coated Film/EC-2 Pressure Sensitive Adhesive has been used, but other adhesives may also be used.



[037] In operation, infrared radiation is produced by the application of a voltage across the electrically conductive heating material 42 that causes current to flow through the material and produce heat. Figures 3a-3d show different arrangements of conductive elements 40 and electrically conductive heating material 42. The arrangements are selected to create uniform heating across the surface of the heating material 42, which produces uniform emission of infrared radiation.

[038] Figures 3a and 3b illustrate applications utilizing a plurality of infrared emitting elements 12. As shown, the individual elements may be activated independently. Systems utilizing multiple infrared emitting elements 12 will be discussed in more detail below.

[039] Another embodiment of the laminate of the infrared emitting element 12 is shown in Figure 4. In this embodiment, the infrared emitting layer 24 further comprises a second plurality of conductive elements 40B disposed on the second surface 38 of the support 34. A second layer of electrically conductive heating material 42B is disposed on the second plurality of conductive elements 40B.

[040] As in the embodiment of Figure 2, the conductive elements 40, 40B of this embodiment may comprise copper electrodes, although other materials may also be used. In one embodiment, the conductive elements 40, 40B and the support 34 are formed from a flexible printed circuit board. In a further embodiment, the support 34 comprises an insulating material. KAPTON has been used for this purpose, but other materials may be used.

[041] As in the embodiment of Figure 2, the electrically conductive heating material 42, 42B may comprise a plastic film, such as conductive thin film, although



resistive element 44 is arranged in a serpentine pattern on the support 34, as shown in Figure 6. The element 44, such as a wire, forms a circuit through which current flows and creates heat. The at least one resistive element 44 may be arranged on the support 34 to form a shape comprising at least one of a geometric shape, a symbol, and an alphanumeric character. As an illustrative example, the resistive element 44 shown in Figure 6 is configured as a chevron.

[047] The infrared emitting element 12 of this embodiment may further comprise a heat dispersion material 46 disposed on the at least one resistive element 44. The heat dispersion material 46 is electrically insulated from the at least one resistive element, such as with an insulating film 47. The heat dispersion material 46 may be secured to the at least one resistive element 44 with non-conductive adhesive. In one embodiment, the heat dispersion material 46 is formed from a material having a high heat conductance. In a further embodiment, the heat dispersion material 46 is formed from a material having a high infrared emissivity. The heat dispersion material 46 may comprise at least one of metal film, paint, and ink.

[048] In operation, the heat dispersion material 46 is heated by the resistive element 44 and produces a uniformly heated surface and, therefore, uniform infrared radiation.

[049] In one embodiment, the infrared radiation generated by the infrared emitting element 12 according to any of the above arrangements has a wavelength above 2  $\mu\text{m}$ . In another embodiment, the infrared radiation has a wavelength in a range between 3 and 14  $\mu\text{m}$ . In this wavelength range, the infrared radiation is invisible to the naked eye, as well as to image intensifiers and night vision equipment.

[050] Alternative embodiments of the infrared emitting element 12 will now be described with reference to Figures 2, 4, and 5. In these illustrated embodiments, the laminate of the infrared emitting element 12 further comprises a first heat insulating layer 48 between the infrared emitting layer 24 and the cover layer 30. In a further embodiment, the laminate of the infrared emitting element 12 further comprises a second heat insulating layer 50 between the infrared emitting layer 24 and the backing layer 32. The first and second heat insulating layers 48, 50 comprise an infrared transparent material. A bubble-filled plastic film comprising polyethylene has been used, but other materials may be used.

[051] In the embodiments illustrated in Figures 2, 4, and 5, the laminate of the infrared emitting element 12 further comprises an infrared reflective layer 52 between the second heat insulating layer 50 and the backing layer 32. In one embodiment, the infrared reflective layer 52 may comprise a metallized plastic film. In another embodiment, the infrared reflective layer 52 may comprise a metallic coating on the second heat insulating layer 50.

[052] The insulating and reflective layers improve efficiency by minimizing heat loss and by directing the infrared radiation in one direction, namely, in the direction of the cover layer 30.

[053] In the illustrated embodiments, the laminate of the infrared emitting element 12 further comprises a sealing layer 54 substantially covering edge portions of the infrared emitting element 12. The sealing layer 54 provides protection against moisture and other environmental elements.

[054] The system control will now be described with reference to Figure 7. In the embodiment shown, the thermal image identification system 10 further comprises a controller 56 electrically communicating with the power source 18 and with the infrared emitting element 12. The controller 56 regulates at least one of an activation of the infrared emitting element 12, an illumination intensity of the infrared emitting element 12, a duration of a pulse of the infrared emitting element 12, a temperature of the infrared emitting element 12, and a voltage of the power source 18.

[055] Thus, the controller 56 may be used to turn the infrared emitting element 12 on and off, to control its brightness and/or temperature, to operate it in a pulsing or flashing mode, and to regulate the system's consumption of power. In addition, multiple thermal image identification systems 10 can be made to operate synchronously, such as flashing simultaneously or emitting infrared radiation at a common intensity or in a common pattern.

[056] In one embodiment, the thermal image identification system 10 further comprises a switch 58 electrically communicating with the controller 56, wherein the controller 56 generates a control signal in response to actuation of the switch 58. The switch 58 allows manual control over the operation of the system 10.

[057] In another embodiment, the thermal image identification system 10 further comprises a control port 60 electrically communicating with the controller 56, wherein the controller 56 generates a control signal in response to an electric signal received through the control port 60. The control port 60 allows operating instructions to be provided, for example, by another computer through a temporary electrical connection, such as a cable.

[058] In another embodiment, the thermal image identification system 10 further comprises a receiver 62 electrically communicating with the controller 56, wherein the controller 56 generates a control signal in response to an input signal received by the receiver 62. The receiver 62 comprises at least one of an infrared receiver and a radio frequency receiver. The receiver 62 allows operating instructions to be provided remotely, for example, using a computer, such as a personal data assistant, a laptop computer, radio transmitter, or other devices.

[059] Thus, the control parameters described above may be selected or updated manually using the switch, electrically using the control port, or remotely using the receiver.

[060] In another embodiment, the thermal image identification system 10 further comprises a temperature sensor 64 electrically communicating with the controller 56, wherein the controller 56 generates a control signal based on a measurement made by the temperature sensor 64. The system 10 according to this embodiment allows a user to adjust the temperature of the infrared emitting element 12. Further, such a system provides temperature stabilization, wherein a constant infrared emitting element temperature is achieved. Alternatively, a constant temperature differential above ambient temperature may be provided.

[061] In another embodiment, the thermal image identification system 10 comprises a plurality of infrared emitting elements 12 arranged contiguously for coordinated operation. The infrared emitting elements 12 may be arranged in a one-dimensional array 66, as shown in Figure 8. In one application, the embodiment of

Figure 8 has been used as a marker for an aircraft landing zone, although other uses are envisioned.

[062] The infrared emitting elements 12 may also be arranged in a two-dimensional array 68, as shown in Figures 9a and 9b. In the embodiment of Figure 9a, strip-shaped infrared emitting elements 12 are used, while in the embodiment of Figure 9b, square-shaped elements 12 are used. It is noted that infrared emitting elements 12 of any shape can be used. Further, these elements can be grouped in an array of any shape.

[063] As used herein, "array" denotes a grouping of plural elements, including elements spaced at equal and unequal intervals.

[064] In one embodiment, the thermal image identification system 10 comprises a controller 56 electrically communicating with the power source 18 and with the plurality of infrared emitting elements 12. The controller 56 regulates at least one of an operating mode of the infrared emitting elements 12, an illumination intensity of the infrared emitting elements 12, a temperature of the infrared emitting elements 12, and a voltage of the power source 18.

[065] In another embodiment, the operating mode comprises at least one of an on mode, an off mode, a pulsing mode, a sequential lighting mode, and a pattern display mode.

[066] In a further embodiment, the pattern comprises at least one of a geometric shape, a symbol, and an alphanumeric character.

[067] Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed

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